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HON. ARTHUR MEIGHEN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

WILLIAM MCINNES, DIRECTOR.

Summary Report, 1919, Part D

CONTENTS

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SUMMARY REPORT, 1919, PART D.

KNEE LAKE DISTRICT, NORTHEASTERN MANITOBA.

By E. L. Bruce.

CONTENTS.

INTRODUCTION.

The examination of the belt of basic Pre-Cambrian rocks in which the headwaters of Hayes river lie was begun in 1919. This seems to be the second largest basin of such rocks in the province of Manitoba and some prospecting had already been done and a few claims staked in the vicinity of Knee lake. Hence it was considered advisable to commence detailed mapping of the area, to give those who might wish to visit that part of the country route maps to assist them in their travels and geological maps to indicate the extent of the formations in which valuable minerals may be expected to occur.

Four months were spent in the areal mapping and geological examination of the country about Knee lake, the lowest large lake expansion of Hayes river. Able assistance in the field work was given by W. J. Embury who did most of the geographic mapping and assisted in outlining the geological boundaries.

The writer wishes to acknowledge very gratefully the assistance and hospitality of Mr. R. A. Talbot, of Norway House, Mr. J. F. Blackford, chief fire ranger for the district, and Mr. W. R. and Mrs. Cargill of Oxford House.

POSITION OF AREA AND MEANS OF ACCESS.

Knee lake is approximately 125 miles northeast of lake Winnipeg. From Winnipeg, it is reached by way of lake Winnipeg, Nelson river, Echimamish river, and Hayes river. Steamers make regular trips from Selkirk to Norway House on Nelson river, from June 1 to the middle of October. From Norway House canoes or York boats must be used. The route follows Nelson river down to the junction with Echimamish river. The current in this part of the river is rapid in places, but only one portage—that at Sea River falls—is necessary. The Echimamish enters the Nelson from the east just below the point where the principal meridian crosses the eastern channels of the Nelson. The Echimamish is ascended to the divide between the Nelson and Hayes drainage basins, a distance of 35½ miles. In this distance there are three dams which are kept closed by stones and logs and the stretches of river between the dams are deep and unobstructed. In high water

boats are dragged up these dammed places, but in low water portages are necessary. The headwaters of the Echimamish are separated from those of the Hayes by a narrow, rocky ledge known as the Painted Stone, over which a portage 100 feet in length is made.

Flowing eastward from the Painted Stone, Hayes river is a sluggish stream 100 to 150 feet in width, with no marked valley, but in places bordered by rock ridges or tongues of glacial debris 20 or 30 feet in height. Seven miles from the divide it receives from the south a tributary which drains Molson lake. This lake is 10 to 12 miles in length and 3 or 4 in width and should really be considered the headwaters of Hayes river. Below the mouth of its tributary the Hayes flows into Whitewater lake, a rather shallow body of water divided into two parts by a narrows. A short distance below the outlet of the lake the first rapids on Hayes river occur. Robinson portage which leads past these rapids is three-quarters of a mile in length. Below the rapids the river meanders sluggishly for 2 or 3 miles through a flat, reedy valley and then expands into another lake. Between this lake and the next lower expansion the river flows through a deep gorge-like valley in a succession of rapids, two of which require short portages. There is also a canoe route by making a 30-chain portage from a northeast-trending bay of the upper lake into another lake which is connected by a long river-like channel with the lower lake. With experienced canoemen the downward journey by the river is preferable. From the expansion below this rapid part of the river no obstructions occur as far as Windy lake. This is an oval body of water 4 miles in diameter, and as the canoe route leads directly across it and there are few islands, travel is frequently impossible on account of the wind. Several rapids occur between Windy lake and Oxford lake, most of which can be run on the downward journey. The last of these, Heponnapanis falls, however, requires a portage of 6 chains.

From Oxford lake the river flows northward for a half mile to Back lake. The outlet of the lake is at the southeast corner and the direction of the river is at first southeast and then east to Knee lake. The total distance is 11 miles. Several rapids occur, two of which, Sharp Rock rapids and Trout falls, necessitate portages of three-quarters of a mile and 6 chains respectively.

HISTORY OF THE REGION.

Hayes river was formerly one of the great trade routes of the west. York Factory at its mouth was the chief post of the Hudson's Bay Company for the distribution of supplies to all the western country. Goods were transported by York boat and canoe to all the inland posts of the Saskatchewan River basin and even across the divide into the Churchill district. This was due to the small number of portages necessary on Hayes river compared with the many portages and long stretches of fast water on the Nelson and the still greater difficulties encountered in the ascent of Churchill river. It was only after the railways from the east began to tap the country about lake Winnipeg that the trade by way of York began to suffer. Gradually it became easier to ship goods in by the railway than by the river and the importance of York Factory has been rapidly diminishing. Now, even the posts in the basin of Hayes river are being supplied through lake Winnipeg and much of the travelling by way of Hayes river to Hudson bay, even after the reversal of the direction of the freight traffic, has been diverted since the construction of the Hudson Bay railway.

The development of mining in Manitoba has led to some renewed interest in the upper part of the Hayes River basin. Early geological exploration proved the existence of an area of rocks similar to those associated with the gold and copper ores of the district north of Saskatchewan river, and a few prospectors in search of new fields paid hurried visits to Oxford and Knee lakes. One party, directed by Mr. H. M. Paull of The Pas, staked a number of claims on the north shore of Knee lake and did a considerable amount of development work on them.

GENERAL CHARACTER OF THE DISTRICT.

Topography.

The Knee Lake district, in common with other parts of the Pre-Cambrian of Manitoba, is characterized by low relief. In some places the surface is hummocky and rugged, but much of the district is so deeply covered by clay and sand that the solid rocks are not exposed and the inequalities of the solid-rock surface are almost completely smoothed out. Along parts of the shores of the lake, ridges of rock are exposed rising 10 to 30 feet above the water. Inland the rocks are covered by fine sand and clay and by muskegs, although the elevation may gradually increase up to the divide between the water systems. Thus from points 4 or 5 miles from the lake the country appears as a plain sloping gently down to the hollow in which the lake lies. The hollow, however, is considerably deeper than the lake at most places. Hence the solid rocks appear beneath the plain as rugged ridges bordering the lake shore.

The country at the south end of Knee lake is the most rugged part of the region. It is underlain by heterogeneous rocks, the resistant bands of which stand up above the more easily eroded rocks. Even in this locality, however, rock exposures do not extend far inland from the waterways. At the lower end of the lake the country is very flat. Rock outcrops are rare even along the shore, and sand and boulder beaches extend for long distances, forming a natural levee behind which lie swamps and muskegs.

Drainage.

Hayes river is the only large river in the area examined and very few tributaries large enough for canoe travel join it in the Knee Lake district. A small creek enters the north end of Back lake. It is used as a canoe route leading to Deer river which empties into the Hayes a considerable distance below Knee lake. Muskegosip creek drains a lake 2 miles in length into the west end of Knee lake. Wolf river drains Swampy Portage lake and Fishing Eagle lake into the large bay south of Magnetite narrows. Though the volume of water carried by Hayes river is not great, it is the canoe and York boat route to Gods and Island lakes. Below Magnetite narrows, Cinder creek empties into the extreme western bay of the lake. It is the outlet of Cinder lake, a body of water 4 miles in length by 1½ in width. Many other small streams flow into the lake, but those mentioned are the only ones of any size. The run-off of large areas seems to be accomplished by a slow seepage through the moss and muskeg, without any definite stream channels.

Industries and Resources.

The fur trade is the oldest and still the most important industry of the Hayes River valley. Much of the country in the immediate vicinity of the river and its lake expansions has been exploited for so long and so intensively that the number of animals taken each year is much smaller than formerly, but this is more than offset by the great increase in the value of furs. In the outlying districts tributary to Hayes river, there seems to be no decrease as yet in the number of skins taken.

The fish and game of the region form a very important source of food for the inhabitants. Some of the lakes are well stocked with good fish; with transportation facilities fishing might become a considerable industry. In Knee lake, however, the fish are not of good quality and are seldom eaten. The animals of the region chiefly used for food are moose and caribou. Unrestricted hunting, the wastefulness of the Indians, and the depredation of wolves have reduced the number of these animals so considerably that probably fewer moose and caribou now exist in this area than in most other areas of the kind.

No systematic examination of the waterpowers of Hayes river has yet been made. In the part of the river above Knee lake there are several rapids and falls which could no doubt furnish considerable energy. Below Whitewater lake, the first

lake expansion of the river, there is a descent of over 60 feet in less than a mile of river. The average flow, however, is probably not very large. Below this is a long, narrow part of the river with several rapids, and by damming the river below Hellgate rapids, power could be developed from these. Between Oxford and Knee lake several rapids occur and the lowest of these, Trout falls, has an almost vertical descent of 15 feet with possibly an additional 10 feet in the rapids below. This should develop a fairly large amount of energy.

Much of the area has been burned over and the second growth trees are still small. In well-drained areas trees attain a fair size, but in the poorly drained areas at some distance from the streams and lakes, growth is very slow and trees seem never to have attained a large size.

GENERAL GEOLOGY.

The rocks of the Knee Lake district consist of a very ancient sedimentary and volcanic complex intruded by quartz-porphyry dykes and by batholiths of granite. These are probably all Pre-Cambrian. Pleistocene deposits consisting of till and stratified sand and clay lie directly upon these old rocks and, over much of the area, are overlain by beds of peat. So much of the region is completely covered by Pleistocene and Recent deposits that it is difficult to determine the relations of the Pre-Cambrian rocks and the following classification must be considered tentative.

Table of Formations.

Recent	Peat.
Pleistocene	Lake clays. Stratified sands. Till.
	Unconformity.
Pre-Cambrian	Granite.
	Intrusive contact (?)
	Quartz porphyry.
	Intrusive contact.
The Pre-Granite Complex	Upper part: lavas, tuffs, and volcanic fragmental rocks with some sediments. Lower part: conglomerate, slate, greywacke, biotite gneiss, etc., with some lava flows.

Pre-Granite Complex.

The oldest rocks recognized in the district form a heterogeneous series that lithologically may be divided into a lower part which is dominantly sedimentary and an upper part which is dominantly volcanic. So far as was observed no unconformity occurs between these two groups.

Sedimentary Group.

The dominantly sedimentary group consists of rusty-weathering gneisses, impure quartzite, slate, conglomerate, tuffaceous rocks, and thin lava flows. These occur in many alternations and no definite order has yet been traced out. The scarcity and small extent of the rock exposures make the problem of sequence especially difficult. It seems, however, that the beds are not continuous, but change in character from place to place along the strike.

Rocks belonging to this sedimentary group outcrop at the rapids between Oxford lake and Knee lake and along the southern shore of Knee lake as far east as the winter trail to Gods lake. Presumably they occupy a large area south of Knee lake, but exposures are not found far inland.

Types of Rocks. The number of this group most commonly seen is a fine-grained, grey gneiss. Exposures along the river below Oxford lake consist of various facies of the rock. It is made up of quartz, feldspar, both orthoclase and plagioclase, and biotite, with brownish red garnets abundantly developed in some bands. The biotite foils lie between the grains of other minerals or cut across them. The biotite is evidently secondary. On the fresh surface the rock is greyish with narrow bands of light and dark shades. In some localities a massive biotite rock occurs which under the microscope is very similar to the foliated rock, but the foils of biotite are not in parallel arrangement. These rocks also contain green hornblende and epidote. Pyrite is present in nearly all specimens. Such massive varieties have been fractured at some period and the fractures are filled with quartz. The quartz veinlets stand in relief as reticulations on weathered surfaces. In the banded rocks there are marked differences in hardness and the narrow, soft bands weather out leaving sharp ridges of hard rock between. The hard layers are attacked transversely to the beds, due to a nodular character that is commonly developed in them. Hence many weathered surfaces are made up of rows of small sharp cones. The Sharp Rock rapids below Oxford lake owe their name to this characteristic of the ledges of rock which cross the river at that point.

A fragmental rock is a very prominent member of this group; it is in part at least a true conglomerate, but in part may be a volcanic fragmental with the fragments somewhat rounded and sorted. The pebbles in some of the exposures are granite, granite porphyry, and quartz, but in many exposures the greater number is a dark, greenstone-like rock very similar to some rocks of the volcanic bands in this group, and to the greenstone that forms the greater part of the upper group. Pebbles of rock similar to the gneisses also occur.

Flow rocks of two types are found. Some of the lavas are fine-grained greenstones very similar to the ellipsoidal greenstone described on page 6. Others are porphyritic and somewhat coarser in grain, are much less altered, and have the composition of andesites. Other more basic types in which diabasic structure is well developed occur. The flows are comparatively thin and are subordinate in total thickness to the sedimentary part of the group.

Many soft black or greenish slaty bands occur in this formation. The most striking of these is a soft, green weathering rock that in places is conglomeratic. The bedding is well marked both by variation in colour and in texture. It has the appearance of a volcanic mud rock. Bands of hard, extremely fine-grained, siliceous rocks occur. They are impure quartzites, consisting chiefly of quartz with some feldspar and considerable biotite, which is, as in the gneisses, secondary, probably due to recrystallization.

Only the chief types of rocks in this group have been referred to in this brief description. Detailed examination will, no doubt, reveal a very large number of varieties.

Structure. At all the outcrops along the river the strike varies from east and west to south 55 degrees east. In places the beds are vertical, but commonly they dip steeply northward. The attitude of the rocks along the lake is the same, with the exception of those exposed in the long, V-shaped bay extending southward. On the north side of this bay the rocks are flatter than at other places, the dip varying from 30 degrees to 40 degrees northwest. On the opposite side of the bay the dip is southeast at about the same angle. The attitude of the beds is evidence of an anticline with its axis along this bay, but the sediments in this locality are cut by pegmatite dykes, and exposures along the south side of the bay are few.

At other places where the beds are somewhat heterogeneous, drag-folding of the softer beds has occurred, but on the whole the members of the group are remarkably consistent in strike and dip.

Volcanic Group.

The rocks of this group are chiefly lavas and associated volcanic rocks. Some minor sedimentary members occur with them, but most of the sedimentary rocks are the abnormal types that would occur locally during a period of volcanic activity.

Character of the Rocks. The volcanic group consists mostly of ellipsoidal weathering greenstone that seems to have had the composition of an andesite. With this there is the usual minor development of amygdaloidal rocks, autoclastic phases and massive types which may have been ash rocks originally. A few bands of ash rocks occur with the lavas, but these are acidic and contain fragments that may be trachyte or rhyolite. These bands are conspicuous as they weather white.

Sedimentary rocks of two types occur in the group. On Painkiller point a narrow band of conglomerate and banded chert outcrops. The conglomerate contains rounded and subangular fragments of chert and greenstone. Some of the pebbles are a foot or more in length. The banded chert has thin, dark grey and light grey laminations, some of which are truncated by later laminations. Across the bay north of this occurrence an outcrop of ellipsoidal weathering greenstone occurs in which the ellipsoids are embedded in chert. Apparently the lava was poured out into water supersaturated with silica which was precipitated as chert. At times there was locally some erosion, truncating chert beds already deposited and producing pebbles which were included in somewhat later deposits. It is probable that the conglomerate is intraformational and does not mark any general unconformity.

The other sedimentary member in the volcanic group is a thin band of iron formation which consists of somewhat granular white silica and magnetite. In the same locality at which the true iron formation outcrops are some exposures of a black slate that belongs probably to the same period. It is very like some of the rocks of the sedimentary group described above.

Structure of the Volcanic Group. If the lavas of the volcanic group are conformable upon the beds of the sedimentary group then the flows along the contact at the southern part of the lake are on the southern limb of a syncline lying to the north. On Painkiller point the banding of the chert dips steeply southward and the truncation of some of the bands indicates that the top is in that direction. Presuming that these beds are on the north limb of the main syncline rather than on a minor fold, the syncline at this point must be narrow, and, as the area of the greenstone series broadens eastward, the syncline probably pitches in that direction. This is corroborated by the pitch of certain drag-folds observed in the iron formation and accompanying slate.

Relations of Sedimentary and Volcanic Groups of the Pre-Granite Complex.

It is believed that the dominantly volcanic group of rocks is younger than the dominantly sedimentary group, but that the two are not separated by any unconformity and represent a thick, practically continuous series. This conclusion is supported by the following facts: (1) The rocks of the sedimentary group in proximity to the volvanic group have dips that vary from 90 to 60 degrees. Where the dip varies from vertical it is in all cases underneath the greenstone series. (2) The rocks are not overturned, since at one exposure at least the top of beds dipping underneath the greenstone appears to be towards the volcanic rock. (3) At one locality there seems to be a gradation from one group to the other.

Rocks of the lower group are well exposed at a point on the south shore 1½ miles west of the winter trail to Gods lake. The dip of the beds is 60 degrees north. At the southern part of the section are distinctly banded slates with alternations of hard siliceous and somewhat softer layers (Figure 1). North of these there is a flow

of andesite or trachyte 10 feet thick, succeeded by a thick band of fragmental material which may be conglomeratic or may be in part tuffaceous. Narrow, tongue-like masses of this fragmental rock extend into the flow (Figure 2). The hypothesis that

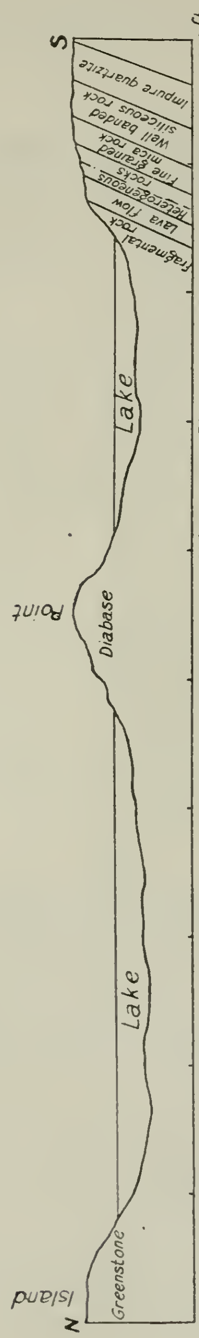

Figure 1. Section showing relation of lower and upper divisions of the Pre-Granite Complex, Knee lake, Manitoba.

seems most reasonably to explain this phenomenon is that as the flow cooled and contracted, cracks formed which were filled by the fragmental rock, whether a normal sedimentary or tuffaceous type. Hence the top of these beds is towards the north and if there be no downfold or fault between the beds exposed and the lavas to the north, the sedimentary group must lie below the volcanic group. There is not sufficient space to allow a fold to carry the sediments above the lavas; and the gradation from sediments to volcanic rock, described in the next paragraph, negatives the idea of a fault.

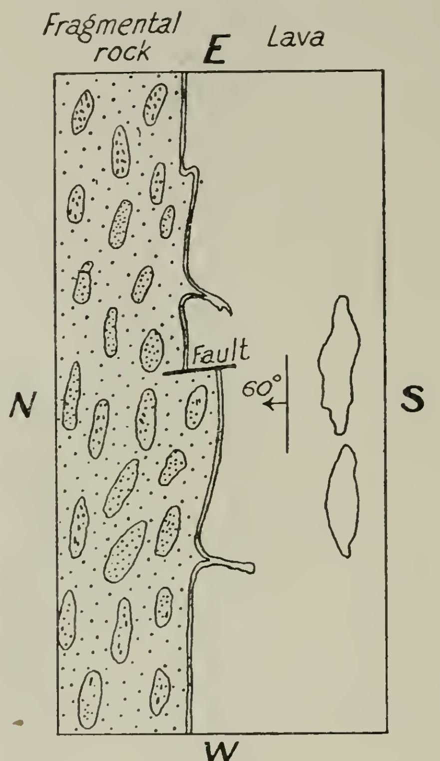

Figure 2. Diagrammatic plan of contact of fragmental rock and lava flow in section. Fragments average about 6 inches in length.

The two groups are in contact on the west end of the large island near the south shore directly south of Paull's cabin. Well-banded, biotite-bearing rocks of the sedimentary group dip northward at an angle of 60 to 70 degrees. The banding of rocks to the northward becomes indistinct and farther on bands of biotite in elliptical forms are developed.

Still farther northward the rock is a typical ellipsoidal-weathering greenstone. This change occurs in a distance of about 100 feet. The following theory of origin is suggested. The well-banded biotite rock of the southern part of the section was probably originally a sediment. Upon this, while still unconsolidated and beneath water, the lavas of the upper group were poured out and formed the typical ellipsoids of subaqueous basic lavas. These ellipsoids by their own weight and the weight of the overlying flows were forced into the yielding muds beneath and the soft sediments were forced into the spaces around the ellipsoids, where they were consolidated and formed the micaceous fillings now found between the ellipsoids. If this view be

correct the volcanic rock is younger than the sediments but forms a member of one great series, the lower part dominantly sedimentary though including some volcanic rocks, the upper part dominantly igneous but with minor amounts of sediments. At various times in the deposition of the rocks of this complex there seems to have been considerable erosion of the beds already laid down and the inclusion of fragments of them in later beds; this erosion was not widespread nor general but merely local, such as is characteristic of periods of volcanic activity.

Quartz Porphyry.

A few dykes of quartz porphyry occur in the Knee Lake district. The rock is granular, with phenocrysts of bluish quartz set in a groundmass of white to pinkish colour. The rock weathers white and is rather conspicuous. It has suffered considerable shearing in places and there is some alteration to sericite. Many of the dykes have been fractured and in the fractures quartz has been deposited. The quartz porphyry cuts the greenstone.

Granite.

Fresh, massive granite outcrops at several places in the area examined. All the outcrops observed along the shores of the lakes north of Back lake consist of granite, and granite occurs along the east shore of Back lake, and dykes of it cut the greenstone. It is to be presumed that the contact trends northeast and that a large area of this rock lies to the northward underneath the heavy cover of clay, sand, and muskeg. A few knolls of granite project through the muskeg between Cinder and Knee lakes. These seem to belong to a small batholith. Granite occurs along the shore of Knee lake south of the mouth of Wolf river and also along the shore of the southeastward-extending bay below the second narrows. These exposures may belong to a great batholith that lies to the southeast.

At all of these localities the granite presents the same appearance. It is fresh and massive and weathers to a faint pink. It is intrusive into the greenstone and granite dykes that cut rocks of the sedimentary group of the Pre-Granite Complex at places along the river between Back lake and Knee lake. Its relation to the quartz porphyry is not definitely known, but since the granite is in all cases fresh and unaltered, whereas the quartz porphyry is in places sheared and metamorphosed, it may be presumed that the granite is the younger rock.

Pleistocene.

Unconsolidated sand and clays of the Pleistocene period rest directly upon the surface of the Pre-Cambrian rocks. It is fairly certain that there were several periods of deposition during the intervening time, but the rocks formed during those periods have been completely removed from the old floor.[1]

During the advance of the glaciers a certain amount of erosion was accomplished with very little if any local deposition. As the ice retreated each stage in its retreat was marked by terminal moraines and outwash fans and plains. As a final stage much of the region southeast of Hudson bay was covered by glacial lake Agassiz, in the bed of which lake clays were deposited. The deposits of the Pleistocene period in the Knee Lake district consist of till, outwash sands, and clays and lake clays.

Till. Unstratified glacial deposits are not commonly exposed in the Knee Lake district. At a few places such material was observed, but most of the true morainal debris seems to have been covered by the later lake deposits.

Outwash Sands and Clays. The most striking deposits of the Pleistocene in this district are the ridges and irregular masses of sand and clay that are believed to be outwash material from the retreating glacier. Some of these deposits have been cut into by the lakes or streams and the cut faces stand up as prominent cliffs that

[1] Geol. Surv., Can., Mem. 105, p. 54.

show the structure of the deposits very clearly. A large area extending from Wapatonisk (White Mud) lake southward along the eastern shore of Pemow lake and the western side of Back lake to Oxford lake is covered by outwash sand and clay. Smaller areas are found along the shores of Knee lake and at various other localities.

The lower beds of the outwash deposits consist of somewhat irregularly bedded sand and clay. The sand is ordinarily very fine-grained. Bedding is distinctly evident on fresh faces and in many layers crossbedding is strikingly developed. The clay beds are light buff or grey in colour and are not distinctly laminated. The clay and sand are interbedded and irregular lenses of pebbles occur in both. The crossbedded sands and the irregular lenses of coarse material were doubtlessly deposited by rapid streams possibly with considerable variation in flow, so that at certain periods the gentler currents could deposit clayey material.

Lake Clays. The lower irregularly bedded material is overlain by beds of finely laminated clay with alternations of grey and chocolate-coloured beds less than one-half inch in thickness. The transition from the greyish or buff clays of the lower part to the evenly-bedded, grey and chocolate-coloured clays of the upper part is usually rather abrupt. The upper beds are somewhat folded. Whether the upper clay is the same as the clay that occurs so widely distributed beneath the muskeg-covered areas is not definitely known, but it probably is. Possibly the melting ice of the retreating glacier gave rise to rapid streams that carried immense loads of debris which was deposited as beds of irregularly stratified clay and sand, in channels or embayments in the thin edge of the melting ice-sheet. The lake formed along the ice front rose as the water from the melting ice flowed into it and, as a final stage, covered this district to some depth. A mantle of regularly bedded clay was deposited during this lake period over the somewhat local sand and clay deposits of the outwash period. A local advance of the ice may have deranged some of these beds and produced the folding that they seem to have undergone in many places.

On some of the larger areas known to be underlain by outwash sands the effect of erosion on sands overlain by lake clays is clearly shown by the vegetation. The usual arrangement of jackpine on the ridges, with spruce or poplar-wooded valleys, is reversed. Jackpine grows in the well-drained valleys; poplar and birch on the ridges. This is due evidently to the removal of the clays, leaving the sandy lower material exposed in the valley, whereas the tops of the ridges are still covered by clay. A striking example of this is the huge ridge between Pemow and Wapatonisk lakes.

Recent.

Recent deposits are represented chiefly by the peat that covers the surface of the older formations in the undrained parts of the region. The flatness of the district and the imperviousness of the lake clays furnish very favourable conditions for the development of bogs and muskegs. Even in places considerably above neighbouring drainage channels peat is found to a considerable depth.

ECONOMIC GEOLOGY.

The character and sequence of the rocks of Knee Lake district are comparable with those of the rocks occurring in districts in which payable ore deposits have been found. Little prospecting has yet been done in any part of Hayes River basin, and the veins found at Knee lake have been disappointing.

The heavy cover of clay and muskeg renders large areas underlain by promising rocks entirely valueless as prospecting fields. In some parts of the district the solid rocks are well exposed and search may be rewarded by the discovery of mineral deposits, but such parts do not constitute more than 2 per cent of the whole area. Besides this handicap the district lies at a great distance from transportation routes, and ore-bodies of only exceptional richness or unusual size would be worth considering. Notwith-

standing these drawbacks the country in the vicinity of Knee lake must not be considered unpromising as a mineral-bearing district. Some of the quartz veins have been shown to carry gold, although the amount in those examined is too small to be profitably extracted. Much of the area, even where the rocks are well exposed, has not been even casually examined and in those parts of the region as good chances exist of discovering ore-bodies as in similar rocks in other districts.

Assuming that mineral deposits are associated with igneous intrusions, the rocks bordering the small intrusions of granite southeast of Cinder lake and east of the second narrows of Knee lake are the most likely localities for concentration of metallic minerals. Any of the rocks prior to the granite may possibly contain veins, but the brittle, massive rocks such as the lavas are more likely to contain large and continuous veins than are the soft and heterogeneous sedimentary beds. The quartz veins that have been found to be auriferous occur in fractured quartz-porphyry dykes.

Mineral Claims.

Claims have been staked at two places in Knee Lake district. One group occupies the eastern end of Magennis island 7 miles from the inlet of the lake, the other group is on a point in Painkiller bay. A few other claims have been staked, but practically all the work done in the district is confined to these two groups.

The Lucky Boy, Apex, Mother Lode, and McIntyre claims are located along the same mineralized zone, two claims lying on each side of it. At the eastern end, the zone lies in a dyke of quartz porphyry, but at the western end the dyke is north of the quartz zone. In the altered and sheared dyke are numerous intersecting veinlets of quartz one inch or less in width. The quartz in the schistose greenstone is in lenticular masses, the long axis parallel to the direction of schistosity. The largest of the lenses uncovered is 25 feet in length and has a maximum width of 12 feet. Some pyrite occurs in the quartz; chalcopyrite and arsenopyrite are sparingly present in the wall rocks. No gold is visible and assays of samples across the main lens at its widest part give only 0·09 ounce of gold per ton.

The claims on the point in Painkiller bay are the White, Davidson, Tilden Smith, and O'Reilly. The point has been almost completely cleared and many trenches have been dug through the clay overburden. The rocks are greenstone and conglomerate with chert and greenstone pebbles intruded by a quartz-porphyry dyke. The dyke has been fractured and in the fractures veins of quartz up to an inch in width have been deposited. The whole body of the dyke was said to carry values in gold, but assays of samples of the quartz veins which seemed to be the most likely source of the gold, show only traces.

CROSS-PIPESTONE MAP-AREA, MANITOBA.

By F. J. Alcock.

CONTENTS.

INTRODUCTION.

General Statement.

Field work for the season of 1919 consisted of the areal mapping of a rectangle including Pipestone lake and a part of Cross lake, northern Manitoba. From previous surveys, the area was known to contain a variety of Pre-Cambrian rocks similar to

those found in the mineralized belt north of The Pas. The field work of the year was to study and map these formations, to report on the possibility of mineral discoveries, and to examine the prospects already staked. A survey of the streams and lakes, including the numerous islands of Cross lake, was made to serve as a control for the geological mapping; the method of surveying was by means of the Rochon micrometer and surveyor's compass with ties to the principal meridian and to the 17th base-line, both of which cross the area.

Acknowledgments.

Thanks are due to many people at Cross lake for their courtesy and hospitality, among whom special mention should be made of Mr. C. H. M. Gordon of the Hudson's Bay Company, Mr. M. McIvor, and the Rev. Mr. Gaudin. Assistance in the field was efficiently rendered by L. G. Thompson of the geological staff of the University of Manitoba, by A. L. Ham, and by E. H. N. Fyles.

Location and Area.

The Cross-Pipestone map-area lies in the province of Manitoba, about 60 miles north of the northern end of lake Winnipeg. The area has for its northern and southern boundaries approximate latitudes 54° 51′ and 54° 24′, respectively; in an east and west direction it includes ranges 1 to 5 west of the principal meridian and range 1 east of the principal meridian. The district mapped has a length of 37 miles, a width of 28 miles, and an area of 1,036 square miles. The northeastern part of Cross lake, with a length of about 20 miles, lies outside the limits of the sheet.

Means of Communication.

Cross lake may be reached from Winnipeg either by way of lake Winnipeg and Nelson river or by way of The Pas and the Hudson Bay railway. The former is the route more commonly used during the summer and is the one by which practically all the supplies and freight for the district are brought in. From the beginning of June until the middle of October a regular weekly steamboat service is maintained between the town of Selkirk on Red river and Warrens Landing at the north end of lake Winnipeg, and from Warrens Landing a tug, the *Victor*, makes weekly trips to Norway House on Nelson river. The journey from Norway House to Cross lake, a distance of about 60 miles, is made by canoe and ordinarily takes from one to three days. Nelson river in this stretch between Norway House and Pipestone lake is divided into several channels on all of which are a number of rapids; the portages for all of these are, however, short. On approaching Pipestone lake, the narrow westerly channel is the route commonly followed. Most of the freight for the region is taken in, however, by another route which avoids all these rapids on the Nelson. Each summer the *Victor* makes several trips with scows from Warrens Landing through Playgreen lake to Whiskey Jack portage on the west branch of Nelson river, where a tramway, 5 miles in length, connects with a bay of Cross lake at its southwestern end. Service, however, in getting supplies both to and across the portage, is so uncertain that parties entering the region with small amounts of freight usually find it more satisfactory to follow the river route.

The summer route to Cross lake from the Hudson Bay railway commences at Thicket portage, 185 miles from The Pas. A portage three-quarters of a mile in length leads to Landing lake, which is followed eastward for a distance of 12 miles to Cross portage. Cross portage has a length of 1¾ miles and leads to the northeastern end of Sipiwesk lake, an expansion of Nelson river, containing numerous islands. Above Sipiwesk lake, either of two channels may be ascended to the point on the river, 2 miles below Bladder rapids, where the Nelson divides. One of these channels leads through Duck lake, but the shorter and more commonly used route follows the eastern branch. Three rapids, Chain of Rocks, Over the Hill, and Red

Rock, respectively, for all of which the portages are short, occur in this part of the route. From this point to Cross lake three more rapids, Bladder, Whitemud, and Shoal, are passed, the portages for which are respectively 22, 40, and 9 chains in length. The whole journey by canoe from Mile 185 to Cross Lake Post usually takes from two to four days.

The winter trail from Cross lake to the Hudson Bay railway follows a shorter route and joins the railway at Mile 137. This is usually a one day's trip by dog team.

Previous Work.

In the summer of 1878 Robert Bell made a track survey of Nelson river for a distance of 180 miles from the outlet of lake Winnipeg; in the same season he also made a track survey of the western channel of Nelson river from Playgreen lake to Cross lake and surveyed part of Cross lake.

In the summer of 1896 J. B. Tyrrell made a track survey of Pipestone and Cross lakes and of some of the channels of the Nelson river included in the map-area.

In 1912, G. H. Herriott surveyed the principal meridian from townships 61 to 72.

In 1913, O. Rolfson cut the 17th base-line from ranges 1 to 20 west of the principal meridian.

GENERAL CHARACTER OF DISTRICT.

Topography.

The Cross-Pipestone Lakes area forms part of the Laurentian plateau and presents the ordinary features characteristic of that great physiographic province. The relief is very low. Pipestone and Cross lakes have an elevation of 683 feet and the average elevation of the plateau surface is about 710 feet. The highest point in the area on the 17th base-line is 764 feet and few if any points in the entire map-area rise to a height of 100 feet above the surface of Cross lake. In detail, the country presents an uneven, hummocky surface with muskeg areas lying in the depressions.

The most important topographical feature of the area is Cross lake itself. A narrow body of water with a total length of 60 miles, 40 of which are included in the map-area, it has an extensive shore-line, the greater part of which is rocky, contains numerous islands, but no broad expanse of water. The total areal extent of the surface of Pipestone lake and the part of Cross lake contained within the map-area barely exceeds 100 square miles. In contrast with this the shore-line has a length of over 300 miles and, including the islands, the total shore-line of the area exceeds 400 miles. The area contains eight islands over 4 miles in length, twenty-seven islands between 1 and 4 miles in length, and over two hundred islands of mappable size less than 1 mile in length, without counting numerous rocky projections too small to be shown.

The entire area is drained by Nelson river. The various channels of the east branch unite in Pipestone lake and the west branch enters Cross lake from the southwest. The only other stream of importance entering Cross lake is Minago river. The Nelson leaves Cross lake by three channels, all of which unite before Bladder rapid is reached. Like most of the rivers of the Laurentian plateau the streams are marked by rapids, falls, and lake expansions, features due to the disorganization of the pre-Glacial drainage by glacial deposition.

Glaciation.

The area shows abundant evidence of having been overridden by continental ice-sheets. Most of the flat rock surfaces are smoothed and striated and in places deeply grooved and furrowed. The small islands and knobs of granite show this glacial scouring particularly well, and by their long, smooth, stoss slopes and abrupt, angular, lee slopes give immediate evidence of the direction of advance of the ice. Numerous observations on the bearings of striæ show three sets, an oldest bearing

south 46 degrees west, a dominant younger set striking south 57 degrees west, and a still younger trending south 82 degrees west. The two first sets represent the main advance of the ice from the northeast and probably mean that an oscillation of the ice front takes place in the region around Cross lake. Observations from a wider field furnish evidence that in its retreat this ice-sheet divided into two lobes, one of which lay northwest of the Cross Lake area and one to the east. The youngest set of striæ indicate that the eastern lobe advanced and over-rode the area. Absence of southerly bearing striæ in the district, however, indicates that the northern lobe in its advance did not reach the Cross Lake area. Deposition by the glaciers was confined to the scattering of erratics and the irregular deposition of drift over the area. The drift is confined largely to depressions and the lee slopes of southwesterly-facing cliffs and is more abundant in the western part of the area than in the eastern.

Population and Industries.

Cross lake has an Indian reservation and a native population which varies greatly in numbers throughout the year, as the Indians travel to and from their hunting grounds. There are two missions, one Roman Catholic and one Methodist, and a number of other white people who are chiefly engaged in the fur trade which is still the most important industry of the area. Agriculture is followed for local purposes only. A large amount of potatoes and other garden vegetables are grown, sufficient for local use; much more could easily be produced if there were easy transportation to an outside market. The Roman Catholic mission has a small sawmill which supplies the lumber needed for the settlement. The best timber is white spruce, which in places forms groves along the lake. The amount of good timber is, however, very limited.

GENERAL GEOLOGY.

The Cross-Pipestone Lakes area lies wholly within the Canadian shield and all of its consolidated rocks are of Pre-Cambrian age. Most of the region is underlain by granite and granite gneiss, but a narrow belt of older rocks extends along either side of Pipestone lake and another belt is found on certain of the islands of Cross lake. Both lakes, therefore, lie in basins of pre-granitic rocks which are bounded by wide areas of granite. The strike of the rocks of the Pipestone area is northwest, whereas in Cross lake it is northeast, following the border of a granite batholith. Deep erosion has uncovered and eroded the granite until only mere remnants of the older rocks into which it was intruded are left today.

The geological succession of the area may be tabulated as follows:

Table of Formations.

Quaternary.	Recent. Pleistocene.	Peat. Lacustrine clays. Glacial drift.
	Great unconformity.	
Pre-Cambrian.	Gabbro and diabase dykes.	
	Igneous contact.	
	Pegmatites and quartz veins. Granite, granite gneiss, etc.	
	Igneous contact.	
	Pre-Granite Complex.	Conglomerate, paragneiss. Volcanics and derived schists.

Volcanics.

The volcanics or greenstone rocks have their most extensive development along Pipestone lake. Some of the islands of Cross lake and a narrow fringe of the north shore of the mainland at the narrows known as Opatika also consist of dark volcanics. In places they show good ellipsoidal structure. Locally they are dense and massive, but all have been more or less altered and in many places have been rendered schistose. In thin section even the freshest looking specimens show extensive chemical alterations. In some sections remnants of original augite crystals remain, but for the most part they have been changed to a light green hornblende. The feldspar has been largely replaced by sericite, epidote, and carbonate, but in some sections there is groundmass consisting of minute feldspar crystals only slightly altered. Iron ore is present in varying amounts. The rocks grade into schists, of which chlorite- and hornblende-bearing varieties are the most common. The latter is a common phase near contacts with granitic intrusives, and in places is garnetiferous.

On an island near where Nelson river enters Pipestone lake and at other points immediately south of Pipestone lake occurs a white rock associated with the greenstone volcanics, which consists almost entirely of labradorite and is, therefore, to be classed as anorthosite. In places the anorthosite contains irregular, oval masses consisting largely of epidote. Locally the adjacent greenstone contains light-coloured masses resembling the anorthosite. A thin section of the rock was found to consist entirely of a part of one labradorite crystal showing both albite and pericline twinning. From its association with the greenstone the anorthosite is considered to be a differentiate from it.

Associated with the more massive volcanics are other fine-grained, dark rocks which show banding and which are considered to be tuffs. In thin section they are seen to be fine-grained, recrystallized rocks consisting of biotite, hornblende, feldspar, quartz, and iron ore.

Porphyry.

With the volcanic rocks are associated certain light-coloured acid types which frequently occur as parallel bands alternating with the dark coloured varieties. In certain places they are seen to cut the more basic types and in other places appear to be cut by them. Some of them, therefore, have the appearance of being interbanded flow rocks, whereas others appear to be dykes. In this section they are seen to be fine-grained rocks consisting of quartz and feldspar. Some of them show phenocrysts of orthoclase, acid plagioclase, and quartz with minor amounts of secondary sericite and carbonate.

Conglomerate, Arkose, Paragneiss.

Three areas of sedimentary rocks belonging to the Pre-Granite Complex are found in the district. The first lies between Cross and Pipestone lakes, the second on Indian Reservation and adjacent islands, and the third along the north shore of Cross lake.

The Pipestone Lake area consists of arkose and conglomerate standing vertically or with steep dips and striking in a northwest direction. Its main development is on the islands lying between the channels connecting Pipestone and Cross lakes, but some of the islands and a fringe of the mainland at the east end of Pipestone lake consist also of similar coarse, clastic sediments. There the succession is from greenstone through finely-banded, dark tuffaceous beds to true sediments which become coarsely conglomeratic. At the west end of Pipestone lake the south shore of the mainland consists of massive greenstone and the adjacent islands are of sedimentary origin. Interbanded between two horizons of conglomerate on the largest island is a band of greenstone 200 feet in width. The sediments vary from

quartzite to arkose and conglomerate. They are poorly sorted and show great irregularities both along and across their strike. Many of the boulders consist of granite; other types include vein quartz, acid and basic volcanics, and porphyry. The granite and vein quartz pebbles are uniformly well rounded, whereas those of greenstone are generally subangular. The series in places is coarsely crossbedded and it is often possible to ascertain the top and bottom of the series by this structural feature. Enough determinations were made to show that the area is complexly folded and faulted and is not a simple syncline bounded on either side by underlying greenstone. At one point the width of a crossbedded horizon between the two main parallel beds is 9 feet. The obliquely lying strata in this bed, also, show alternating coarse and fine layers with conglomeratic bands up to 14 inches in width and finer gravel bands up to 16 inches in width. It is a type of crossbedding suggestive of torrential river deposits.

The second area of sedimentary rocks is on the south and west shores of Indian Reservation island and on other adjacent islands. The rock types include a finely banded quartzite and sedimentary gneiss with conglomeratic horizons. The rocks are intruded by granite and pegmatite and in places it is difficult to distinguish between the sedimentary gneisses and the banded gneisses forming the border zones of some of the granitic intrusions. The presence of boulders was the conclusive evidence of sedimentary origin. Finely banded, garnetiferous gneisses which resembled the matrix of the conglomeratic bands were also regarded as of a sedimentary origin. On the northwest shore of Indian Reservation island is found a band of greenstone lying between two horizons of conglomeratic sedimentary gneiss. The lower horizon is coarsely conglomeratic, consisting largely of boulders of granite which have been squeezed out parallel to the contact with the adjacent intrusive granite. The matrix of the conglomerate is a fine garnetiferous gneiss.

The third area consists of a strip of the mainland near where Nelson river leaves Cross lake, and of some of the adjacent islands. The main rock type is a finely banded gneiss which is nearly everywhere garnetiferous. Locally, certain bands contain rounded pebbles and boulders, chiefly granite. The matrix of these conglomeratic bands is exactly similar to the sedimentary gneiss of other localities in the area. The dips are nearly everywhere vertical and the strike is here northeast, following the shore of the lake. In places a hybrid rock formed by lit par lit injection of granite along the bedding planes of the sediments has been produced.

Thin sections of the sedimentary gneisses from various localities of the map-area show very similar features. The commonest type is a fine-grained biotite gneiss. The biotite consists of small shreds, most of which have a parallel orientation. In some sections muscovite is equally abundant and a few large crystals sometimes are seen. Orthoclase and a little plagioclase are always present. The most abundant mineral, however, is quartz which consists of fine, interlocking grains. Accessory iron ore and apatite are usually present and garnet crystals are found in some sections.

No evidence was found to suggest that the conglomeratic sediments overlie unconformably the volcanic rocks. No pebbles of schistose greenstone were found in the conglomerates and all the different types of dyke rocks that were seen to cut the volcanics, pegmatite, gabbro, and diabase, also cut the sediments. In places, greenstone was found interbanded with conglomeratic gneiss and arkose. The dominantly clastic character of the sediments, with the total absence of limestone and a minimum of shale, the irregular character of the bedding, and the great thicknesses point to a continental, probably fluviatile origin for at least much of the series.

Granite, Etc.

Granite and granite gneiss cover much the larger part of the map-area. They vary from red to grey in colour and in texture from massive to gneissoid. The commonest variety is biotite granite. In thin section the principal minerals present are feldspar, quartz, and biotite. The feldspar consists of orthoclase, acid plagioclase, usually albite, and minor amounts of microcline. Apatite and iron ore occur as accessory minerals.

Near the border of the batholiths the granite in places is a hornblende variety commonly containing both biotite and hornblende as its ferromagnesian constituents. In places for several miles from the contact of the greenstone and granite, the granite contains blocks of greenstone which apparently represent stoped fragments.

On the north bank of Nelson river, below Whitemud falls, the granite gneiss is well banded and breaks along parallel planes which have a low dip to the north, so that from the river the rock resembles a sedimentary formation. The texture of the rock in hand specimen, however, is typically granitic and in thin section the rock is seen to be a biotite granite consisting of quartz, orthoclase, albite, biotite, with accessory apatite and iron ore.

Pegmatite dykes are common in the region, cutting both the granite gneiss and the bordering intruded rocks. They are usually fairly coarse-grained, consisting of quartz and orthoclase feldspar. Several dykes were seen in which large black crystals of tourmaline were abundant and which also contained small crystals of garnet.

Gabbro and Diabase.

Throughout the area dark coloured dykes are found cutting the granite and older rocks. They are of two types, large coarse-grained dykes and small aphanitic dykes.

The large dykes are found in greatest abundance on the south channel of Nelson river where it leaves Cross lake. For a distance on the channel, known as the "Elbow," outcrops of gabbro occur along the banks on either side, suggesting that the channel was eroded along the strike of a large dyke. The rock is coarse-grained, dark grey to black in colour, and massive. In thin section it is seen to consist dominantly of labradorite feldspar and augite. The augite is largely altered to secondary minerals, chiefly chlorite. A small amount of green hornblende occurs in some sections. Iron ore is present in all the sections.

Small dykes of diabase are found everywhere throughout the region, cutting the granites. One outcrop was found where a pegmatite dyke cuts conglomerate and is in turn traversed by a narrow, black diabase dyke. In thin section one specimen shows rounded phenocrysts of augite in a fine-grained groundmass consisting of augite, epidote, and iron ore penetrated by lath-shaped crystals of labradorite. The augite phenocrysts are also traversed by the feldspar crystals.

Pleistocene and Recent.

The deposits of glacial origin consist of till left in depressions and other protected places. After the retreat of the Pleistocene glaciers, the region was covered by a lake in which was deposited fine lake clays. The Recent deposits consist of peat bogs in areas where there is poor drainage.

ECONOMIC GEOLOGY.

Owing to the limited extent of the rocks of the Pre-Granite Complex, the area is not promising from a prospecting point of view. The intruded rocks are limited to a narrow belt on either side of Pipestone lake, several narrow discontinuous strips along Cross lake, and to some of the islands of the two lakes. The wide areas of granite that underlie the rest of the region represent batholiths which have been uncovered and deeply denuded by long-continued erosion. The narrow belts of the older complex represent mere remnants of formations caught between rising batholiths or parts of the same batholith, and they have had less chance of becoming mineralized by solutions from the ascending magma than the roof which was removed by erosion in pre-Ordovician time.

A few claims have been staked on the north shore of Pipestone lake and on an island near where Nelson river empties into Pipestone lake. On the north shore of the lake the rocks are greenstones, in places ellipsoidal and in places altered into chlorite schist. The discovery consists of a vein of bluish and milk-white quartz about 4 feet in width but containing no traces of visible mineralization. Trenching through the overburden on the property has revealed other occurrences of quartz which on account of the presence of sulphides looked more promising. Assays, however, of grab samples gave only traces of gold; one sample ran silver at the rate of 0·42 ounce Troy to the ton of 2,000 pounds.

The mineral claim situated on the large island at the point where Nelson river enters Pipestone lake contains schist mineralized with arsenopyrite, pyrite, and small amounts of chalcopyrite and bornite. A white anorthosite rock associated with the schist is also mineralized. An assay of a sample, however, yielded negative results for both gold and silver.

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The annual Summary Report of the Geological Survey is now issued in parts, each designated by a letter of the alphabet. Part A contains the report of the Directing Geologist, reviewing the work of the Geological Survey for the year and containing lists of reports and maps published during the year, and is accompanied by a table of contents for all parts of the annual Summary Report.